Forecasting of Professional Serviceability in Dangerous Conditions

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ABSTRACT

The necessity of work in a dangerous environment is a serious problem for organization of military units activities. This problem is also actual for liquidation of emergency situations and at some industrial plants. From its correct solution depends physical and mental health of workers, and sometimes their lives. This requires a thorough review of medical service organization to the extent that goes beyond the activities in a peaceful situation. There are many studies aimed at the effects of certain environmental factors on staff. Forecasting of professional serviceability in dangerous conditions of individual professionals, small groups and large contingent allow correct planning of peacekeeping, antiterrorist, search and rescue operations. Research shows the main (basic) behavioral reaction in a man to life threat conditions.

Research also revealed that functional status organism and professional workability of staff is closely correlated with periods of psychical tensions during work. This expectance period of emergency situation of danger, a hazard period (acute or prolonged action) and the period of work after completion of the danger. Aggregate index of psychical tension is sufficiently objective indicator of subjective perception of danger and psychical tension, which arose in conditions threat to life. Verbal descriptions of life-threatening conditions can make a forecast of subjective perception of danger staff correctly enough. Reduced workability of staff, caused by life threatening conditions, can vary from 5 to 50%. A complex of measures on preparation to work in life threatening conditions can reduce this influence by 10-20%. In the case, when staff is uncertain in reliability of protection irrational behavior and panic may occur. Preventive use of protective equipment, audio duplication for optical "danger" signal, previous training in simulator significantly reduces the negative influence of threat to life on the workability of staff under effect of information load.

Working with dangerous substances or equipment is perceived as a local threat and leads to less psychical tension. Working in conditions of danger which is perceived as dangerous environment (global threat) causes more mental tension. Staff can leave a dangerous work area when there is a local threat. It's difficult for staff to leave a dangerous area if necessary when there is a global threat. Working in conditions threat to life requires a careful prognostication of positive and negative aspects of preventive

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use of protective equipment and finding ways to reduce its negative influence on the professional workability of staff.

INTRODUCTION

The necessity work in environment of danger is a serious problem for the organization of activities of military units [1, 2]. This problem is actual also for liquidation of emergency situations and some industrial plants. From its correct solution depends physical and mental health of workers, and sometimes their lives.

NATO forces are increasingly involved to conduct peacekeeping, anti-terrorism, search and rescue and humanitarian operations under UN auspices. Peace support, search and rescue, anti-terrorism operations require careful planning, rapid decision-making, taking into account the human factor and the possible consequences. Organization and planning of such operations meet with many difficulties. In most cases, the time allotted for the preparation of the operation is limited, since the operation is a forced reaction to the already existing situation. Regions of operations often have sanitary and epidemiological hazard.

Threat remains use of chemical weapons in the conflicts. Growing number of countries with their own nuclear program weapons and nuclear energy and could potentially get hold of nuclear and radiological weapons.

New dangers appear. Many countries and terrorist organizations have access to technology of making radiological, chemical and biological weapons.

There is a possibility of use of chemical and radiological weapons, radioactive materials, highly toxic compounds of agricultural and industrial use. To create a mass destruction the dangerous production, storehouse, transport may also be deliberately shattered. Because of technogenic load, there is an increased the risk of large-scale accidents at hazardous production (radiation, chemical, biological) that are not associated with terrorism or fighting, as for example in Bhopal, Goiânia, Chernobyl, Novosibirsk [3, 4, 5, 6, 7]. General global trend is an extension of the tasks from military medicine to medicine of catastrophes.

This requires a thorough review of medical service organization to the extent that goes beyond the activities in a peaceful situation. There are many studies aimed at the effects of certain environmental factors on staff [8].

[1.] Annan K. A., Millennium Report of the Secretary-General of the United Nations, We, the Peoples, The Role of the United Nations in the 21st Century, UN document A/54/2000, 3 Apr. 2000, pp. 5-6, available at URL http://www.un.org/millennium/sg/report/ .

[2.] Щорічник СІПРІ 2002: Озброєння, роззброєння та міжнародна безпека/ Пер. з англ.., Українське видання Щорічника СІПРІ підготовлене спільно Стокгольмським міжнародним інститутом дослідження миру та Українським центром економічних і політичних досліджень імені Олександра Разумкова.– К. „Заповіт”: 2002. – 800 с

[3] Bisanti Y., Bonetti F., Coramosehi F. Experiences from the accident of Seveso. -Acta morphol. Acad. Sei hung. -1980.- 28. - Nl, N2.-S.139-157

[4] Чернобыльская катастрофа // Барьяхтар В.Е. (редактор). – Киев, Наукова Думка, 1995. – 568 с

[5] Уткин А. Химический «Чернобыль»// Гражданская защита 1993.- №8.-С.31-33

[6] Радиационная авария в Гоянии МАГАТЭ, Вена, 1989 STI/PUB/815

[7] Carus WS. The Rajneeshees (1984). In: Tucker JB, ed. Toxic terror: assessing terrorist use of chemical and biological weapons. Cambridge, MA, MIT Press, 2000, 115-137.

[8] Dishovsky, Christophor; Pivovarov, Alexander A. (Ukrainian State Chemical Technology University) Counteraction to Chemical and Biological Terrorism in East European Countries Springer, 2009, 324p.

At the same time, the lack of common methodological approaches, traditionalism in the views of individual schools and the constant evolution of threats, protective equipment and military equipment are not allowed to present a structured system of medical support of troops in danger, which would meet current needs.

Forecasting of professional serviceability in dangerous conditions individual professionals, small groups and large contingent allow correct planning of peacekeeping, antiterrorist, search and rescue operations.

For most peaceful extreme professions threat to life, as an active factor, formed by natural causes and not specifically directed against the individual. For these occupations ambient conditions of activity form only a certain, usually low-probability threats to life that can occur when adverse circumstances or worker safety violation take place.

The need for research of this factor is related to its priority place in the system of motivation sphere of activity, of unique importance in the formation of labor intensity and depth of unconditional and conditional behavioral responses aimed at preserving human life.

As a result, dangerous conditions significantly influence the quantitative and qualitative indicators of professional performance of military personnel and must be considered when planning.

One of the main features of military personnel activity, which distinguishes it from other extreme professions, is the nature and level of threat to life.

The necessity of military action in conditions of NBC threat, for example such as the destruction of environmentally hazardous industrial facilities, dramatically increases the probability of combined lesions and irretrievable loss. In peacetime, in a special group the work associated with elimination of accidents and other cases where there is a threat to life and health of employees, can be distinguished.

Thereby, we can affirm that the study of mental stress as a reaction to dangerous conditions, and the effects of such stress on professional performance are important and have their own specificity.

The main objectives of the study were:

1) Obtaining data on objective indicators of human functional state, which can be correlated with levels of human mental state in dangerous conditions.
2) Creating a single objective criterion of psychic condition people in dangerous conditions.
3) Determination of the dynamics of professional workability of staff in dangerous working conditions.
4) Construction of mathematical models that predict the professional workability of staff in dangerous working conditions.

METHODS

To construct a mathematical tool for forecasting we used data on direct indicators of occupational performance and functional status of specialists. Employees performed the work with certain physical, informational and emotional workload. Microclimatic conditions matched WBGT 22°C, 29°C.

Professional workability of staff was evaluated as separate functions, which are important for work in conditions of mainly physical, informational, emotional workload or their combination [9].

[9] Khudetskyy Igor ACCOUNTING MODELS OF THE HUMAN FACTOR AND ITS ARCHITECTURE IN SCHEDULING AND ACCEPTANCE OF ADMINISTRATIVE SOLUTIONS// North Atlantic Treaty Organization, RTA, HUMAN FACTORS & MEDICINE PANEL, HFM-202 Symposium “HUMAN MODELLING FOR MILITARY APPLICATION” 18-20 October 2010

It also displays the functional state of the organism, but is focusing on the important parameters for successful professional activity (physical power, reaction speed, sensorimotor coordination, thinking, attention, long-term and operational memory, etc.)

To determine the success of professional activity in each particular point of time was offered an aggregated factor for determining professional capacity for work (**$A_{пп}$**). It is calculated for separate components of professional work and can correctly use the experimental data for the forecasting for real people. The specific contribution is determined by the requirements of professional work.

$$A_{ППП} = \frac{1}{n} * \sum_{i=1}^{n} k_i * \left| \frac{(\chi_i - \chi_{\min})}{(\chi_{\max} - \chi_{\min})} \right| , \quad (1)$$

n – quantity of important parameters of professional capacity for work ;
k – weight coefficients of each parameter of professional capacity for work;
x_i – parameter value at the time of study;
x_{min} – minimum value of this parameter;
x_{max} – maximum value of this parameter.

Evaluation of efficiency for the entire period of work carried out on indicators of efficiency (Pi), which takes into account changes in quantitative and qualitative parameters of professional activities and their contribution to the final result can be stated as follows:

$$P_I = \int_{\tau_o}^{\tau_\phi} f(A_{ППП}) * d\tau , \quad (2)$$

this

P_i – integral of all the works for the whole experiment;
t_0,$t_ф$ – time, respectively, the beginning and the end of work;
$A_{пп}$ – aggregated factor for determining professional capacity for work;
dτ – time integral.

Effectiveness of professional staff is estimated as the ratio of obtained generalized index of efficiency to the required values:

$$E = \int_{\tau_o}^{\tau_\phi} f(A_{ППП}^{Ф}) * d\tau \Big/ \int_{\tau_o}^{\tau_Н} f(A_{ППП}^{Н}) * d\tau , \quad (3)$$

this

$A_{ППП}^{Ф}$ – actual value of aggregated factor for determining professional capacity for work;
$A_{ППП}^{Н}$ – necessary value of aggregated factor for determining professional capacity for work

t_0, $t_ф$, $t_н$ – time, respectively, the beginning work, the actual completion of work and time required.

Information loading was created by using the modified test KK Ioseliani "arithmetic calculations in mind with forced pace" and other tasks by receiving and processing information in the free and forced pace, using an automated system of psycho-physiological experiment and complex research and diagnostics equipment.

Physical loading was given by bicycle ergometer. Level of physical activity was set according to recommendations of Romanenko VA , 1999.

Individually dosed psychoemotional loading simulation created varying degrees of threat to. The developed laboratory models have allowed to rather adequately simulate the conditions of danger and to reproduce psychic tension associated with a various degree of uncertainty about the successful completion of work in dangerous conditions.

Primary parameters of functional state of the organism were determined by generally accepted methods using available equipment. To evaluate the functional state of personnel the most informative indicators of functional body systems that are crucial to professional workability of staff were used: cardiovascular (heart rate) and of thermoregulatory (core body temperature and sweat loss). For general evaluation of functional status it is appropriate to use aggregate indices. They were based on the indicators that varied in the same range. Aggregate indicators of functional status were determined using two indexes that were proposed by the author.

Index of functional tension is defined as the average change of indicators used for calculation:

$$\mathbf{IFTO} = \left(\frac{\mathbf{P-70}}{\mathbf{100}} + \frac{\mathbf{T-36,5}}{\mathbf{2}} + \frac{\mathbf{M}}{\mathbf{2}} \right) \div \mathbf{3}, \tag{4}$$

this

IFTO – index of the functional tension (index FTO).
P – pulse rate at the time of measurement, beats / min;
T – rectal temperature at the time of measurement, °C;
M – sweat loss at the time of measurement, kg/hr.

This index can correctly estimate the functional state of a person at any time having one value.

In evaluation of the alterations of the functional state over a period of activity, especially if changes of functional state were of nonlinear nature, the definition of this index is inadequate. Index FTO ignores the time factor, i.e. it does not take into account the duration of functional abnormalities, but it is necessary to assess the psychical fatigue and functional reserves of organism. To estimate changes in functional status over time the index FTO was integrated over time and an Index FTO was obtained.

$$\mathbf{IFTO-I} = \int_{\tau 0}^{\tau 1} \left(\left(\frac{\mathbf{P-70}}{\mathbf{100}} + \frac{\mathbf{T-36,5}}{\mathbf{2}} + \frac{\mathbf{M}}{\mathbf{2}} \right) \div \mathbf{3} \right) d\tau \tag{5}$$

,

this

τ_1 – time workload, hours.

Analysis of experimental data revealed that the index FTO determines the ability of workers to continue working and make a brief prognosis of conditions for these activities. Its value within 0.1 - 0.5 shows that the work can be continued, while a change of this index within 0.5 - 0.7 is usually one of the criteria of functional status beyond the maximum permissible values. When changes of this index are within 0.8 - 0.9 value of all criteria of functional state exceeds the maximum permissible level.

Integral value of this index FTO-I shows the state of body reserves and the possibility of recovery. If the value of this index is less than 0.6 professional capacities can be restored within 3-4 hours by 90%.

RESULTS, DISCUSSION

Studies were conducted in several stages. First, based on interviews with experts who had much experience in the eradication of dangerous accidents, was developed by a formal verbal gradation of dangers.

At the first level of danger the works, which are not life threatening but can cause large health disorders with blatant violation of regulations and work safety, have been included. Also in this list the work that require protective equipment for the save of health have been included.

At the second level the works, potentially life-threatening without use of special protective equipment, but even when using special protective equipment with a threat of violation of health, were included.

At the third level the works in a situation of dangerous accidents when there is danger to life and use of protective equipment not always gives full guarantee of safety, were included.

The main types of human behavior as a reaction to the threat were also received. First of all it is the mobilization of attention, the preventive use of protective equipment, excessive protection, avoidance of danger situation, the termination of professional activity, irrational behavior (panic), which could harm the employee or others. According to experts, the type of human response to risk is directly related to his personal experience, completeness of information on conditions and situation, the behavior of others.

In the first series of experimental researches changes parameters of functional state-psychological correlates of tension staff for formal gradations of threat to life were studied. Table 1 shows the changes of parameters in functional state that correlate with psychic tension while simulating different levels of danger to life in the laboratory.

The data obtained allow to evaluate psychic tension by objective indices of functional status, but significant individual variability does not allow for each parameter, taken separately, to develop a scale of psychic tension.

The proposed aggregate index to a certain extent smooths out individual features and response largely reflects the actual level of threat to life. To calculate aggregate index the data presented in Table 1 were converted into units of a single scale using the formula (6).

Table 1: Changes of parameters of functional state that correlate with psychic tension for different levels of danger.

Parameters of functional state		Levels of danger			
		0 control	1	2	3 accident
Heart rate, bpm		68±4	75±3	84±4	112±12
Dispersion of heart rate, bpm		8.3±0.7	4.3±0.3	2.3±0.1	1.6±0.2
Blood pressure, mm Hg	Systolic	112±4	123±6	142±8	175±16
	Diastolic	70±6	70±8	82±4	83±9
Respiratory rate, breaths/min.		11±2	12±3	14±2	14±6
Minute ventilation L/min.		12±0.5	14±0.7	15±0.7	17±1
Anxiety, standard units		31±4	42±5	48±3	48±3
Self-reported state, standard units.		4.8±0.3	4.3±0.2	4.0±0.2	3.2±0.4
Activity, standard units.		5.8±0.2	6.4±0.3	6.8±0.4	3.6±0.2
Frame of mind, standard units.		5.1±0.4	4.7±0.3	4.2±0.3	2.8±0.6
Skin resistance, kOhm		80±10	60±5	40±5	20±7

$$\chi_\gamma = (x_i - x_i^f)/(x_i^{\max} - x_i^f), \quad (6)$$

this

$X_i, X_i^{\max}, X_i^f$ – the current value of the i-th indicator, its maximum and the background value.

The converted data which were obtained as a result of the calculations are given in Table 2. The values of composite index of mental tension largely coincided with the expert-level risk assessment and subjective perception of threat to life. In subsequent studies this data was used to determine the level of individual and subjective perception of threat to life.

Table 2: Changes of parameters of functional state that correlate with psychic tension for different levels of danger that have been converted in units of a uniform scale.

Parameters functional state, units uniform scale.		Levels of danger		
		1	**2**	**3 (accident)**
Heart rate, bpm		6	14	59
Dispersion of heart rate, bpm		42	73	84
Blood pressure, mm Hg	Systolic	27	64	100
	Diastolic	0	36	37
Respiratory rate		6	8	9
Minute ventilation		15	17	21
Anxiety		22	35	24
Self-reported state		7	12	26
Activity		6	13	28
Frame of mind		6	13	33
Skin resistance		26	50	78
Aggregate index psychic tension		14.8	30.5	45.4

The next phase of research was performed for two groups of employees. Members of the first group previously disclose specific working conditions and level of danger, which is studied. Members of the second group performed the work after routine instruction without prior explanation of the study type. Members of the second group personally identified level of hazards during the work.

An aggregate index of psychic tension by the formula (4) was also calculated

$$\gamma = \sqrt{1/n \sum_{i=1}^{n} (\chi_{\gamma i})^2}, \quad (7)$$

Functional status of the employee including professional functions that are important for work, were assessed before and after working in hazardous conditions, and at the end of six hours of the experiment with the information workload. Some indicators of functional status and settings correlate with mental stress that was being continuously recorded. For a more complete assessment of professional functions that are important to the work the test on individual physical endurance 0.765 P170 on bicycle ergometer was used with the information workload which increased signal-tasks to the critical frequency (the efficiency of information processing in full range of workload).

These data confirm a certain level of activation of functional systems of the body which would meet the needs of professional activities in danger.

Indicators of functional status, which were registered during in the first and second level of threat to life, not extended beyond the optimal values for this workload (Table 3).

Staff worked with the informational workload after stopping the threat to life.

The functional state quickly normalized and corresponds to data in control measurements. Ending index of the functional state of body tension after six hours of standard duty was practically no different from controls. Restoration of some indices of functional state at the second level of threat to life took place more slowly and tended to stabilize at higher values. Thermal condition of the body has not changed significantly. To set the microclimatic conditions protective equipment and workload were used.

During the first part of the experiment (work in dangerous conditions) slight accumulation of heat and heat redistribution between the core and shell, which wouldn't be changed in the second part experiment, was observed.

In control studies this dynamic thermal state was observed in the first 30-40 minutes with mainly informational workloads. Somewhat different was the dynamics of functional status of work in "emergency situation". Changes of functional state of the body were significantly higher compared with the control and lower levels of risk.

This is especially true in heart rate, which increased by 49% compared with minimal threat to life, and systolic blood pressure - increase was up to 42%

The data obtained differ considerably with individual variation, depending on experience and some other indicators. Self awareness played a particular role: sufficient or insufficient measures taken for complete safety and the consequences for life and health.

This can be explained by a significant deviation of recorded results. During the subsequent six-hour operation of the informational load was observed only a certain tendency towards restoration of functional state. Integral index IFTO-I for the study was located at a level that is comparable to physical activity. Three participants out of 15 who participated in this experiment refused to continue the research during the first two hours of information workload.

Similar to change in the functional state of the body changed the professional workability of staff in conditions informational workload. Conditions of threat to life of first and second level, which occurred in the period before work, do not significantly affect the workability staff in the first hour of work.

Table 3: Changes functions, which are important for work, under the influence threat to life before the work (microclimate WBGT 22 ° C).

Indicators which were investigated		Awareness and the level of threat to life during the work					
		Control	1 (Awareness)	1 (No awareness)	2 (Awareness)	2 (No awareness)	3 (No awareness)
Reliability (optimal workload information), %	start	94,2±4,3	94,1±3,9	94,3±3,8	93,2±4,3	92,3±4,6	82,3±8,9
	end	92,1±3,3	92,3±3,8	92,2±3,6	91,1±4,1	90,2±4,5	80,2±7,3,
Efficiency of information processing (in whole range workloads), %	start	83,9±3,1	86,3±4,2	87,1±3,2	84,8±4,1	84,1±4,2	59,4±4,3
	end	73,7±3,4	73,7±3,3	75,4±3,7	73,7±3,4	75,4±3,7	70,1±3,8
Critical frequency presentation signals, c.	start	3,5±0,1	3,5±0,1	3,5±0,1	3,5±0,1	3,5±0,1	4,5±0,1
	end	4,3±0,3	4,2±0,2	4,3±0,2	4,3±0,3	4,3±0,2	4,5±0,3
Operative memory, s.u.	start	12,1±1,3	12,3±1,6	13,5±1,4	11,8±1,3	11,6±1,4	10,2±1,5
	end	10,6±2,5	10,5±2,3	11,4±1,3	10,2±2,5	10,1±1,3	8,6±2,2
Concentration attention, s.u.	start	346±7	356±6	354±11	339±9	332±11	287±13
	end	322±16	312±9	314±18	304±16	301±9	237±9
Aggregate index sensomotor coordination, s.u.	start	0,94±0,04	0,96±0,03	0,96±0,02	0,95±0,04	0,95±0,02	0,82±0,03
	end	0,82±0,06	0,81±0,04	0,81±0,03	0,8±0,06	0,8±0,03	0,76±0,04
Aggregate workability, s.u.	start	0,96±0,03	0,97±0,03	0,97±0,02	0,95±0,03	0,94±0,02	0,82±0,03
	end	0,88±0,04	0,87±0,03	0,87±0,02	0,85±0,04	0,85±0,02	0,74±0,05
Maximum time work, min		>360	>360	>360	>360	>360	>360
Index FTO –I, s.u.		5,53±0,16	5,53±0,17	5,53±0,22	5,41±0,16	5,37±0,14	4,71±0,12
Effectiveness activities, %		92,1±2,3	92,2±3,6	92,1±1,7	90,1±2,3	89,4±2,1	78,4±4,0

For the first and second levels of threat to life after the successful completion of the dangerous conditions were observed growth of of concentration attention and volume of operative memory, changes in other functions that are important for the work were not statistically significant.

Threat to life, which occurred in the period before work and connected with the accident situation, at the first hour of work led to a decrease of workability staff by 14%. Result of work in accident situation was decreased over the long period of basic functions that are important for the work. Decrease touched effectiveness of information processing (30%), mainly due to the critical frequency presentation signals (28%). Somewhat less decreased of concentration attention (17%) and volume of operative memory (16%).

For the first and second level of threat to life further informational workload resulting in decrease aggregate value performance indicator in addition to value on 10-12%. This is about as in control experiments. For accident situation it was 13,7%., ($p > 0,05$).

Implementation within six hours of acceptance and processing information from the load factor of 60% of the total budget time as not led to a substantial redistribution of of detected trends and reflected in efficiency of information processing and aggregate workability. Some differences in level of occupational disability was found depending on the nature of the information load after the threat to life. Change workability staff when optimal and extreme informational workload after exposure to conditions of threat to life during, before work shown in Fig. 1 and Fig. 2.

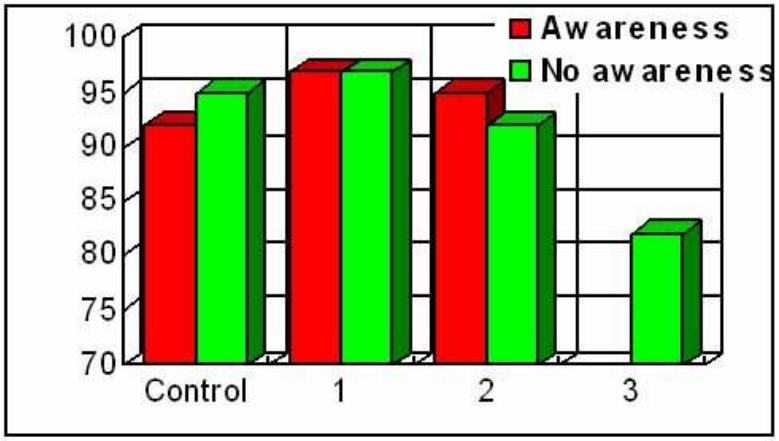

Figure 1: Professional workability of staff when work in conditions of threat to life and optimal informational workload.

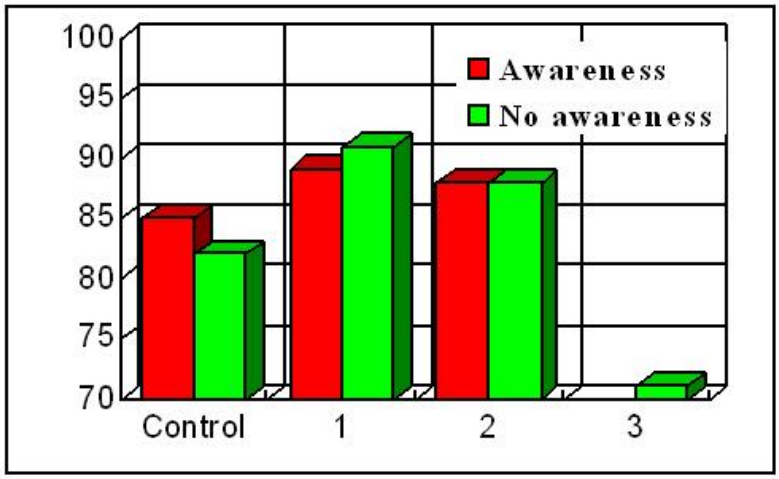

Figure 2: Professional workability of staff when work in conditions of threat to life and extreme informational workload.

Considering the peculiarities of the perception of risk when working in hazardous atmosphere were performed a series of additional research. These researches were classified as chronic psychoemotional influence on parameters of "the duration of threats to life (up to six hours).

In these researches was studied the effectiveness of preventive use of protective equipment in comparison with using them after signal danger, influence fatigue, the possibility of adaptation, need for duplication signal of emergency situation, independent choice of security and use of protective equipment, use of protective equipment in a dry hot climate.

Functional state staff fully examined before and after the experiment. Criterion indexes and functional condition indexes - correlates of psychical tension continuously registered. Changes of functional state of the organism in During this series of experiments to microclimate conditions WBGT 22 shown in the table. 4.

Table 4: Changes functional condition of staff at long-term danger in the process of information workload (WBGT 22°C).

Indicators which were investigated		Procedure for use of protective equipment		
		CONTROL	PREVENTIVE	SIGNAL "DANGER"
Core body temperature, °C	start	36,5±0,3	36,5±0,2	36,5±0,2
	signal "danger"	36,6±0,3*	36,9±0,1	36,6±0,1
	end	36,7±0,1	37,1±0,1	36,8±0,1
Heart rate, bpm	start	65±4	74±4	81±6
	signal "danger"	74±4*	96±7	116±11
	end	76±6	82±5	89±4
Systolic blood pressure mm Hg	start	116±3	124±5	132±6
	signal "danger"	112±4*	142±8	157±18
	end	105±14	121±9	124±11
Diastolic blood pressure, mm Hg	start	71±3	76±4	78±5
	signal "danger"	64±5	80±7	84±8
	end	56±7	72±5	78±7
Average skin temperature, °C	start	33,3±0,2	33,3±0,2	33,3±0,2
	signal "danger"	33,4±0,3*	33,7±0,3	33,3±0,1
	end	33,4±0,3	34,0±0,3	33,5±0,2
Average body temperature, °C	start	35,8±0,2	35,9±0,2	35,8±0,2
	signal "danger"	36,3±0,1	36,6±0,2	36,2±0,2
	end	36,4±0,2	36,8±0,2	36,5±0,2
Accumulation of heat in the body, kcal / kg	Before "danger"	0,35±0,09*	0,53±0,13	0,34±0,11
	After "danger"	0,07±0,05*	0,18±0,04	0,17±0,05
	overall	0,42±0,13	0,77±0,15	0,51±0,14
Vital capacity (lung), l	start	4,6±0,2	4,7±0,2	4,7±0,2
	end	4,1±0,3	3,8±0,3	4,1±0,3
Delay time breathing on inspiration, c	start	56,5±3,9	56,5±3,9	56,5±3,9
	end	49,9±6,1	41,3±6,8	43,8±6,7
Sweat loss, kg/hr		0,21±0,07	0,34±0,07	0,26±0,07
Effectiveness vaporization of sweat,%		64±8	16±6	67±8
Index FTO (signal "danger"), s.u.		0,03*	0,19	0,20
Index FTO (end), s.u.		0,07	0,18	0,14
Index FTO –I, s.u./hr		0,40	0,96	0,90

Note: * Data are given for 120 min in research "control"

As seen from the data, the dynamics of functional condition reflected the influence of protective equipment, that were used, and threats to life.

When using protective equipment preventive or in their application for signal "danger " was clearly defined waiting period. Heart rate and systolic blood pressure were significantly higher than to same period of control.

Minimal changes in these rates (7% and 13%) were registered when the protective equipment with increased safety features used preventive, the maximum change was when the protective equipment with optimum characteristics used after the signal "danger". Accordingly, in the latter case, the systolic blood pressure and heart rate increased by 14% and 24%.

Dynamics of heat condition the body, which was recorded during this series of experiments, generally correspond data obtained for the equivalent conditions in control.

Were Identified some statistically unconfirmed increases core body temperature. In our opinion, this may be a result of increased physical activity during the experiment, which is known, is one of the manifestations of anxiety.

After switching signal "danger" and other attributes of the implementation of realistic simulations of danger functional state staff has changed considerably. Observed changes were the same trends as in the waiting period. They were less pronounced in experiments with preventive use of protective equipment and largely manifestated when used after switching signal "danger" Further dynamics of functional status, especially correlates of psychical tension, in most cases had tended to normalize.

Changes functions, which are important for work, at long-term danger in the process of information workload (microclimate WBGT 22°C) shown in the table 5.

Table 5: Changes functions, which are important for work, at long-term danger in the process of information workload (microclimate WBGT 22°C) , X±σ.

Indicators which were investigated		Procedure for use of protective equipment		
		CONTROL	**PREVENTIVE**	**SIGNAL "DANGER"**
Reliability (optimal workload information), %	start	94,2±4,3	92,4±3,8	84,3±5,9
	signal "danger"	-	89,2±4,1	78,1±4,2
	end	92,1±3,3	83,1±3,9	82,1±7,5
Efficiency of information processing (in whole range workloads), %	start	83,9±3,1	81,2±4,1	67,1±4,2
	signal "danger"	-	77,9±4,1	54,3±6,2
	end	73,7±3,4	69,4±3,4	65,4±5,4
Critical frequency presentation signals, c.	start	3,5±0,1	3,6±0,1	4,3±0,2
	signal "danger"	-	3,8±0,3	5,2±0,4
	end	4,3±0,3	4,4±0,3	4,5±0,3
Operative memory, s.u.	start	12,1±1,3	11,8±1,3	9,6±2,1
	signal "danger"	-	11,2±1,3	8,2±2,1
	end	10,6±2,5	8,2±2,5	8,1±1,3
Concentration attention, s.u.	start	346±7	312±12	219±16
	signal "danger"	-	289±11	173±21
	end	322±16	217±16	219±17
Aggregate index sensomotor coordination, s.u.	start	0,94±0,04	0,89±0,03	0,78±0,07
	signal "danger"	-	0,81±0,04	0,65±0,08
	end	0,82±0,06	0,79±0,06	0,73±0,05
Aggregate workability, s.u.	start	0,96±0,03	0,92±0,03	0,76±0,05
	signal "danger"	-	0,86±0,03	0,65±0,05
	end	0,88±0,04	0,73±0,04	0,71±0,04
Maximum time work, min		>360	>360	>360
Index FTO –I, s.u.		5,54±0,16	4,97±0,16	4,24±0,16
Effectiveness activities, %		92,4±2,3	82,8±2,3	70,7±2,5

Comparative analysis of the data presented in table 5, with data on the influence of protective equipment on the functional status and parameters functional state-of correlates psychic tension (tabl. 4) allow to conclude that the threat to life has a significant impact on professional workability. Professional

workability was lower compared with the control in all cases when was the threat to life at 10-20 %. It was also observed that the efficiency of professional activity in conditions of danger to life increases by 3-4% in the presence of dubbing signal "danger" (optical and acoustic). This trend has taken place, and where protective equipment is used after the signal "danger" and where protective equipment is used prophylactic.

When protective equipment used after the signal about the danger of reduc workability was larger (up to 10%) than with its preventive use. This additional decrease was caused by the fear to miss a signal "Danger". It should be borne in mind that the application of protective equipment after the signal "danger" staff from one up to five minutes almost completely excluded out of work.

Later there is a gradual the workability restoration if there is self-confidence about the reliability of protective equipment and have control of the situation.

Dynamics of professional working capacity for long-term danger is shown in Fig. 3. Professional workability decreased up to 50% when the situation was perceived as an emergency or unplanned. In this case, the number of refusals to continue the work increased. When took place situation that in employees had suspicion in the absence of reliable protection of all the further conduct of staff was directed to exit from the working area to a safe area. Professional activities ceased completely in this situation. Usually stopped work in accordance with the protocol of an emergency stop.

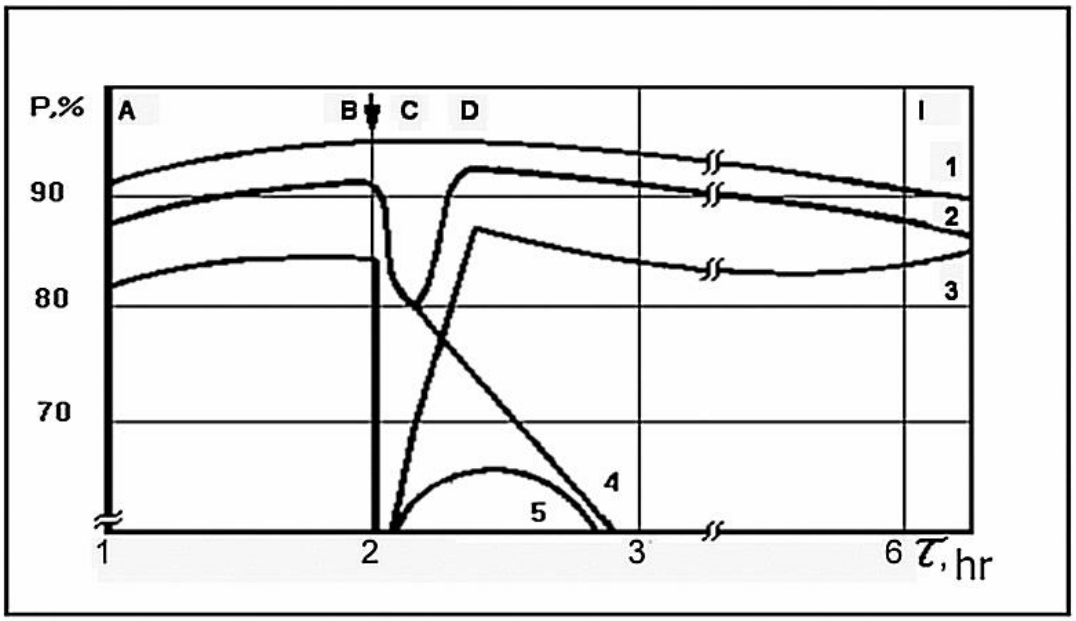

Figure 3: Dynamics of professional working capacity for long-term danger.

1. Control
2. Preventive use of protective equipment
3. Protective equipment is used after the signal "danger"

4,5. Irrational reaction

▼signal "danger"

In some cases employees leave a job without a minimum complex of actions to stop equipment. It was then observed irrational the behavior, often on the background of extreme emotional disturbance.

Typically, the overall decline of professional workability was within 5-20% depending on the individual characteristics of mental and staff working conditions. At the same time was a period when the staff in fact does not work.

Psychogenic influence threat to life on the staff has its own characteristics in conditions hot climate. First of all, is correlated with the similarity of subjective perception of signs of overheating, and certain lesions (radiation, chemical, biological).

Accumulation of heat in the body of staff was on 57-62% higher in the waiting period, when the protective equipment used preventively in compared with the use of protective equipment after the signal "danger". This distinction was even more so if the waiting period lasted longer.

The observed facts can be concluded that the threat to life had a significant impact on professional performance when working with information load in a hot climate. Workability staff was lower compared with the control in all variants of work in conditions the threat to life.

Preventive use of protective equipment led to decrease professional capacity at 4,6-9% in the waiting period. This decrease was caused by a combination of unfavorable microclimatic conditions, thermophysical properties of protective equipment and load. After signal "danger", this index decreased even additional at 9-14%. Using protective equipment after the signal "danger" led to decrease professional capacity at 16-21% in the waiting period. After signal "danger", this index decreased even additional at 9-11%.

Compare dynamic working capacity in conditions of threat to life by a factor analysis revealed precise interrelation between the conditions of professional activity and decrease working capacity. It was found that preventive use of protective equipment, audio duplication for optical signal "danger", previous training in simulator significantly reduces the negative influence of threat to life on the workability staff at action of information load. Especially important were training with simulation of emergency situations.

In conditions at mainly physical activity preventive use of protective equipment because of their depleting influence has not led to improvement of professional working capacity, although the staff were perceived it as more secure (Fig. 4,5).

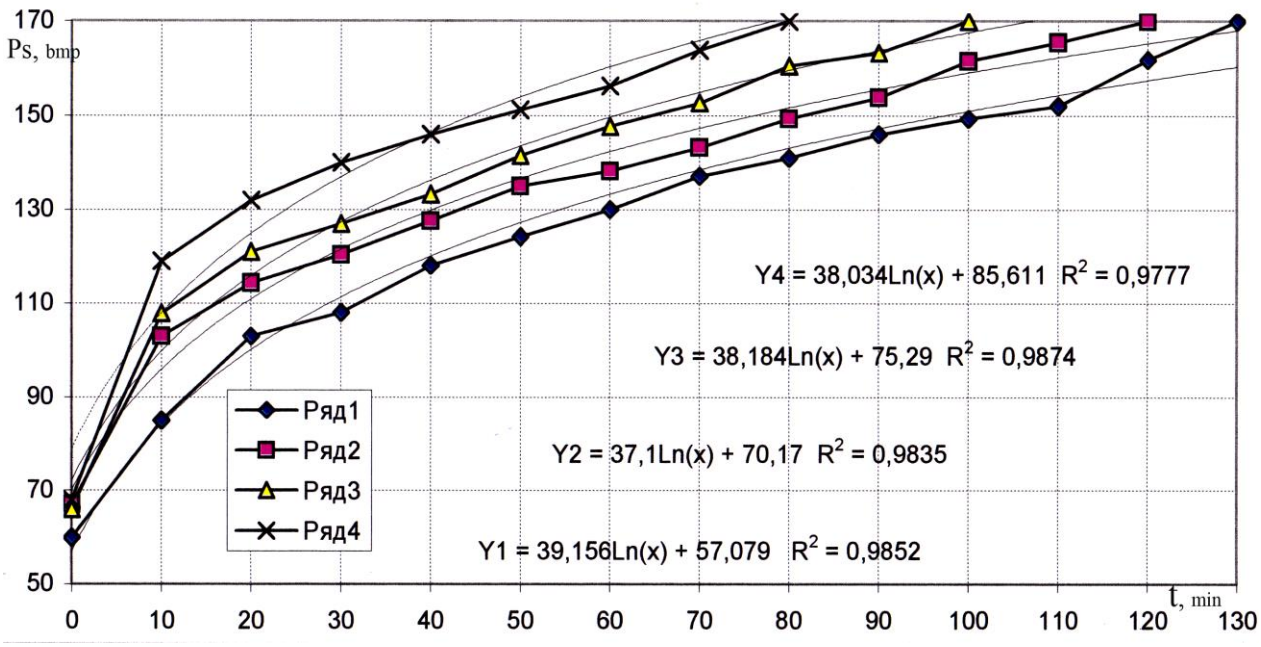

Figure 4: Dynamics of heart rate during ergometric test 0.765 PWC_{170}, when the threat to life.

1 – Control, protective equipment is not used
2 – Protective equipment is used after the signal "danger"
3 – Control, protective equipment is used
4 – Preventive use of protective equipment.

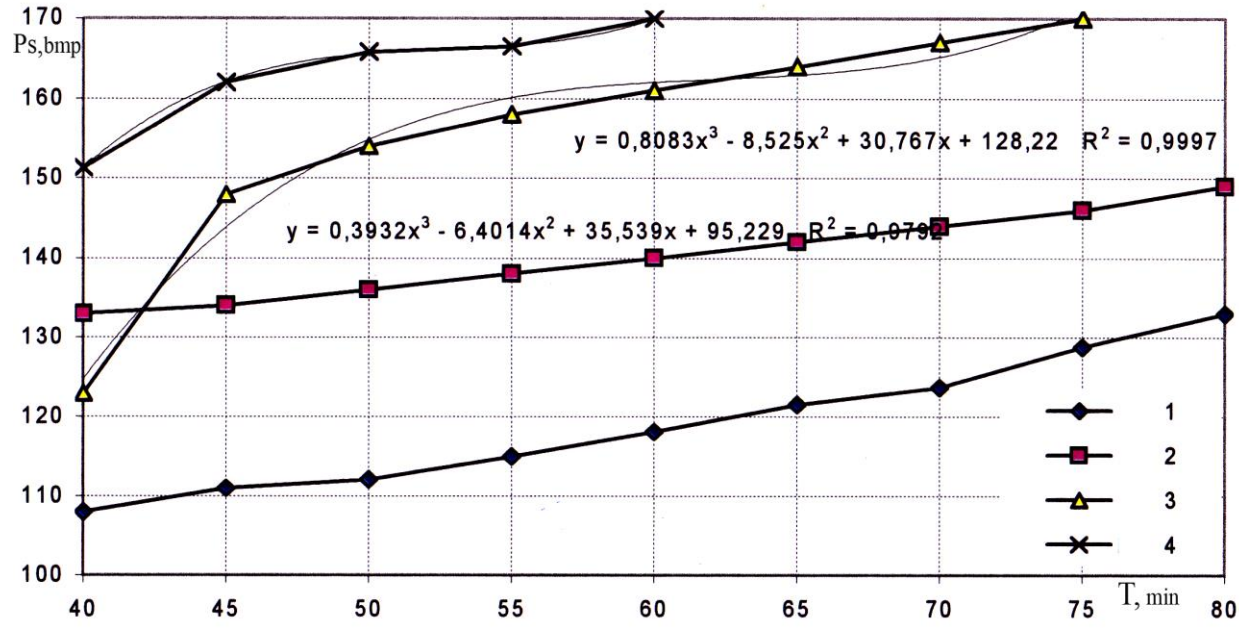

Figure 5: Dynamics of heart rate during ergometric test 0.765 PWC170 after the signal "danger".

1 – Control, protective equipment is not used
2 – Control, protective equipment is used
3 – Protective equipment is used after the signal "danger"
4 – Preventive use of protective equipment.

Independent significance for determining the level of psychical tension has been the selection of protective personnel equipment. Data on the typical desire to use excessive protection in case of low experience of the staff, new procedures for them to work or incomplete information about working conditions, was validated.

CONCLUSIONS

1) Functional status of organism and professional workability of staff is closely correlated with periods of psychical tensions during work. They include waiting period of a situation of danger, a hazard period (acute or prolonged action) and the period of work after completion of the danger.

2) Aggregate index of psychical tension is a sufficiently objective indicator of subjective perception of danger and psychical tension, which arose in life threatening conditions.

3) Verbal descriptions of life-threatening conditions can make a forecast of subjective perception of danger for staff correctly enough.

4) Reduced workability staff, caused by life threatening conditions, can vary from 5 to 50%. A complex of measures on preparation to work in life threatening conditions can reduce this influence by 10-20%. In the case, when staff is uncertain in reliability of protection irrational behavior and/or panic may occur.

5) Preventive use of protective equipment, audio duplication for optical "danger" signal, previous training in simulator significantly reduces the negative influence of threat to life on the workability of staff under th effect of information load.

6) Working with dangerous substances or equipment is perceived as a local threat and leads to less psychical tension. Working in conditions of danger which is perceived as dangerous environment (global threat) causes more mental tension. Staff can leave a dangerous work area when there is a local threat. It is difficult for staff to leave a dangerous area if necessary when there is a global threat.

7) Work in life threatening conditions requires a careful prognostication of positive and negative aspects of preventive use of protective equipment and finding ways to reduce its negative influence on the professional workability of staff.